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UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office

May 20, 2003

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APPLICATION NUMBER: *60/374,054*
FILING DATE: *April 19, 2002*
RELATED PCT APPLICATION NUMBER: *PCT/US03/11969*

By Authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS

N. WOODSON
Certifying Officer

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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

Express Mail Label No. EL759994685 US

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Jill MacDonald	Boyce	Manalapan, New Jersey (USA)

☐ Additional inventors are being named on the _____ separately numbered sheets attached hereto

TITLE OF THE INVENTION (280 characters max)

Synchronization Loss Resilient Digital Communications System using Forward Erasure Correction

CORRESPONDENCE ADDRESS

Direct all correspondence to:

☐ Customer Number

OR

Type Customer Number here

Place Customer Number Bar Code Label here

☒ Firm or Individual Name	.JOSEPH S. TRIPOLI, THOMSON MULTIMEDIA LICENSING INC.	
Address	PATENT OPERATIONS.	
Address	P. O. BOX 5312	
City	PRINCETON	State NJ	ZIP 08543-5312
Country	USA	Telephone 609-734-9444	Fax 609-734-9700

ENCLOSED APPLICATION PARTS (check all that apply)

☒ Specification Number of Pages   4   ☐ CD(s), Number _____

☐ Drawing(s) Number of Sheets _____   ☐ Other (specify) _____

☐ Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT (check one)

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check or money order is enclosed to cover the filing fees

☒ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 07-0832

☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT ($)   160

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are: _____.

Respectfully submitted,

SIGNATURE _____

TYPED or PRINTED NAME   Ronald H. Kurdyla

TELEPHONE 609 734-9701

Date   4/19/02

REGISTRATION NO. (if appropriate)   26,932

Docket Number: PU020125

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

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FEE TRANSMITTAL
for FY 2002

Patent fees are subject to annual revision.

Complete if Known

Application Number	
Filing Date	Herewith
First Named Inventor	J.M. Boycet
Examiner Name	N/A
Group / Art Unit	N/A

TOTAL AMOUNT OF PAYMENT	($)	160	Attorney Docket No.	PU020126

METHOD OF PAYMENT (check one)

1. ☒ The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:

Deposit Account Number: 07-0832

Deposit Account Name: THOMSON multimedia Licensing Inc.

☒ Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17

☐ Applicant claims small entity status. See 37 CFR 1.27

2. ☐ Payment Enclosed:

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FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Fee ($)	Small Entity Fee Code	Fee ($)	Fee Description	Fee Paid
101	740	201	370	Utility filing fee	
106	330	206	165	Design filing fee	
107	510	207	255	Plant filing fee	
108	740	208	370	Reissue filing fee	
114	160	214	80	Provisional filing fee	160

SUBTOTAL (1) ($) 160

2. EXTRA CLAIM FEES

		Extra Claims		Fee from below		Fee Paid
Total Claims	-20 ** =	0	X		=	0
Independent Claims	-3 ** =	0	X		=	0
Multiple Dependent			X		=	0

Large Entity Fee Code	Fee ($)	Small Entity Fee Code	Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	84	202	42	Independent claims in excess of 3
104	280	204	140	Multiple dependent claim, if not paid
109	84	209	42	** Reissue independent claims over original patent
110	18	210	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 0

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Fee Code	Large Entity Fee ($)	Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet.	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	400	216	200	Extension for reply within second month	
117	920	217	460	Extension for reply within third month	
118	1,440	218	720	Extension for reply within fourth month	
128	1,960	228	980	Extension for reply within fifth month	
119	320	219	160	Notice of Appeal	
120	320	220	160	Filing a brief in support of an appeal	
121	280	221	140	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive – unavoidable	
141	1,280	241	640	Petition to revive – unintentional	
142	1,280	242	640	Utility issue fee (or reissue)	
143	460	243	230	Design issue fee	
144	620	244	310	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Processing fee under 37 CFR 1.17 (q)	
126	180	126	180	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	740	246	370	Filing a submission after final rejection (37 CFR § 1.129(a))	
149	740	249	370	For each additional invention to be examined (37 CFR § 1.129(b))	
179	740	279	370	Request for Continued Examination (RCE)	
169	900	169	800	Request for expedited examination of a design application	

Other fee (specify) _____

*Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($) 0

SUBMITTED BY

Name (Print/Type)	Ronald H. Kurdyla	Registration No. Attorney/Agent	26,932	Telephone	609.734.9701
Signature				Date	5/19/02

Complete (if applicable)

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Synchronization Loss Resilient Digital Communications System Using Forward Erasure Correction

Wireless digital communications systems are subject to multi-path and fades, which can lead to loss of synchronization. The data transmitted during periods of lost synchronization would normally be lost to the receiver. A copending application describes a system to repeatedly transmit data (staggercasting) in order to recover from the data lost during failure of equalizer synchronization. This disclosure proposes to use Forward Erasure Correction (FXC) codes to recover from synchronization loss, by treating periods of sync loss as packet erasures. Additional parity data to recover from those packet erasures is transmitted in a backwards-compatible manner. This allows a reduction in the overhead rate, as compared to repeatedly transmitting data, but with a cost of increased delay and storage requirements.

Wireless digital communication links suffer from multi-path and fading effects. These effects are well understood and their probability characteristics have been documented. For example, in ATSC 8VSB transmission systems for HDTV broadcast in the United States, the probability distribution of fade duration has been studied. Reception of the 8VSB system on a mobile device further increases the probability of synchronization loss. Even after synchronization is reacquired, useful data can not be recovered in an ATSC 8VSB system until trellis decoding is re-trained, and the interleaver begins a new block.

The problem to be solved is how to design a system that is resilient to synchronization loss due to multi-path and fading, with as low an overhead rate as possible.

The ATSC 8VSB system includes several types of channel coding to protect against noisy transmission, including trellis coding, interleaving, and Reed Solomon Forward Error Correction. But when synchronization loss occurs, the channel coding methods used do not assist in recovering the data.

Repeatedly transmitting data, as in the staggercasting disclosure, can improve system resiliency synchronization loss, but at the cost of high overhead. Allocating more of the available bandwidth to repeated transmission of data reduces the amount of original data that can be transmitted, which means fewer programs, or lower quality of transmitted programs.

It has also been proposed that instead of repeatedly transmitting the original data, the overhead rate could be reduced by redundantly transmitting a lower bitrate version of the original data. When the original data is lost due to synch loss, the reduced resolution version is used by the receiver. This allows graceful degradation -- a lower quality version of the original data is available rather than the original data.

Forward Erasure Correction (FXC) codes have been applied to transmission of packet data, to protect against packet loss, for transmission of data over packet networks, such as those using Internet Protocol. Reed Solomon (RS) Forward Erasure Correction codes are systematic codes, i.e., the original information bytes are transmitted, and additional parity bytes are transmitted. In the absence of channel loss, the receiver can merely use the received original information bytes, and does not need to do any FXC decoding. Packet networks tend to lose entire packets worth of data, rather than individual bytes in packets. When FXC is used to protect against packet loss, typically one byte from each packet is used to form an FXC codeword. For example if 10 packets of length 1024 bytes were coded using FXC, using RS (15, 10) codes, 10 information packets of length 1024 and 5 parity packets of length 1024 would be transmitted. 1024 different RS codewords would be formed by taking one byte from each packet.

Protection against data loss due to synchronization loss in a digital communications system can be achieved by adding a layer of Forward Erasure Correction (FXC), with the parity data computed over time periods corresponding to expected length of synchronization loss periods. Periods of data loss due to synchronization failure are considered to be packet erasures in the FXC decoder. Because the term packet is generally used to refer to a smaller time scale in this system, such as an MPEG-2

transport packet of 188 bytes, in this disclosure the term superpacket will be used to refer to a packet unit used in the FXC decoder.

The proposed invention is independent of the type of data that is being transmitted, and can be used for the transmission of any type of data, and is not limited to audio/video programs. In the proposed invention, the FXC is used in addition to other channel coding methods in the digital communications system that protect against impulse noise. For example, in the ATSC 8VSB system, FXC coding is added to the system's trellis coding, interleaving and Reed Solomon (RS) Forward Error Correction (FEC) coding. The FXC used can be any systematic forward erasure correction code, such as Reed Solomon (RS) codes. When a systematic code is used, the proposed invention can be backwards compatible. The FXC encoder and decoder differ from the RS FEC codes already used in the existing system. The FXC codewords are computed across superpackets, one byte per superpacket, and protect against loss (erasure) of entire superpackets, while the existing RS FEC protects against random bit or byte errors, not erasures, inside a given packet, with the samples taken from nearby points in time.

The FXC parameters n and k, and the superpacket length, s, are selected based on desired loss protection level and allowable delay. The expected length of lost synchronization should be $s * (n/k) * h$, (where $h = n - k$) or less. The overhead rate for the FXC encoding is n/k. So, for example, in a system that broadcasts 19.2 Mbps = 2.4 M Bytes/sec, to protect against a fade of 500 msec, $s * (n/k) * h <= 1.2M$ Bytes. If, for example, $n = 6$, $k = 4$, ($h = 2$) the overhead rate is 50%, and $s = 400$ kbytes. Additional storage is required for the proposed invention, beyond what a standard ATSC 8VSB system would require, of $s * n$ bytes, which for this example is 2.4 M Bytes. If multiple programs share the 19.2 Mbps channel bandwidth, storage requirements could be reduced by performing the FXC decoding only for the program being decoded.

Figure 1 illustrates a transmitter, which adds FXC to the ATSC 8VSB digital communications system. The FXC encoder block is placed after the source coder, but before the transport mux and channel coding blocks. k superpackets, each of length s, are input to an FXC encoder. The FXC encoder generates $h = n - k$ parity superpackets of length s. The original information superpackets and the parity superpackets are then multiplexed, using the transport mux. The ATSC 8VSB system uses MPEG-2 Transport Streams in the transport mux, which allows multiple programs to be multiplexed and sent over the same channel, with each program assigned a different PID. In the proposed invention, the information superpackets are unchanged from a system that does not use FXC. In the invention, additional parity superpackets are transmitted, which are assigned different PIDs by the transport mux than the information superpackets. If multiple programs are to be transmitted, each with a different PID, the parity superpackets can be either be computed based on all programs together, or based on one or more individual programs. All data is then sent to the remaining channel coding portions of the ATSC 8VSB, which are unchanged from a standard system. To assist in synchronization at the receiver, special FXC Sync Transport Packets can be sent under a different PID, once for each n superpackets. These FXC Sync Transport Packets would indicate the correspondence between superpacket sequence number start positions with MPEG-2 Transport Packet PID and program_clock_reference (PCR) and continuity_counter fields, superpacket length, s, and the Reed Solomon (n, k) parameters.

Figure 2 illustrates a receiver based on the ATSC 8VSB system with additional FXC decoding. The FXC block is placed after the other channel decoding blocks and transport demux, and before the source decoder. Superpacket sequence numbers and positions can be determined using the FXC Sync Transport Packets. Erasure positions are also necessary for an FXC decoder, which can be made available to the FXC block using an error indication signal from one of the prior channel coding blocks, such as the Reed Solomon decoder. For use in an MPEG-2 Transport Stream system, the transport_error_indicator field in the transport packet can be used to indicate the location of errors.

If no synchronization loss occurs, FXC decoding is not necessary, and the FXC decoder just passes through the data in the information superpackets to the source decoder. If synchronization loss occurs, and is detected, those superpackets with missing or corrupted data are marked as erasures. If k or more superpackets are received correctly, whether information or parity superpackets, the FXC decoder

perfectly reconstruct the missing information packets, by performing decoding of s RS(n, k) codewords, taking one byte from each superpacket to form the codewords.

For example, in a system with FXC RS(6,4), 6 superpackets of length 400 kBytes are transmitted. Superpackets 0 - 3 are information superpackets, and 4 and 5 are parity superpackets. Superpackets 3 and 4 are corrupted at the receiver due to synchronization loss. FXC decoding is performed on 400 thousand codewords, each formed by taking the ith byte of superpackets 0, 1, 2, and 5, with the 3rd and 4th positions marked as erasures. Superpacket 3 is perfectly reconstructed by the FXC decoder, and superpackets 0 - 3 are sent on to the source decoder. Figure 3 illustrates this example.
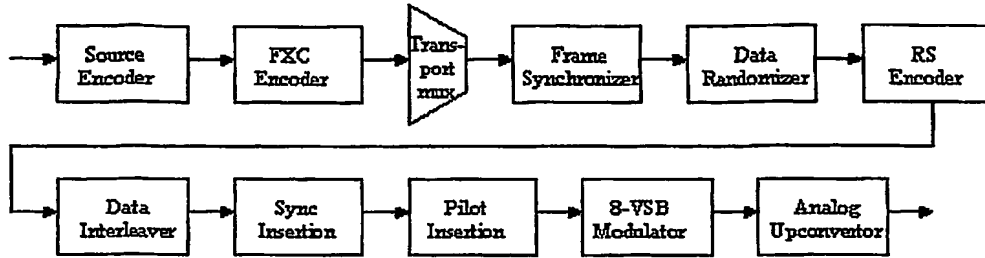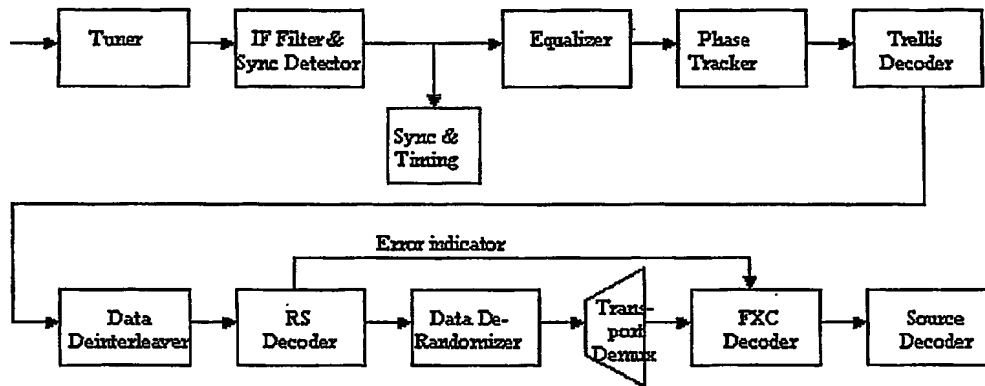
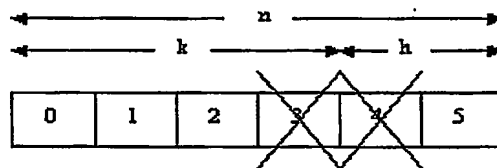Figure 1. VSB Transmitter with FXC

Figure 2. VSB Receiver with FXC

Figure 3. Example pattern of superpacket loss